Northern Illinois University

Your Future. Our Focus.

Seeing the Unseen: Inquiry Driven Campus Hydrogeology Project

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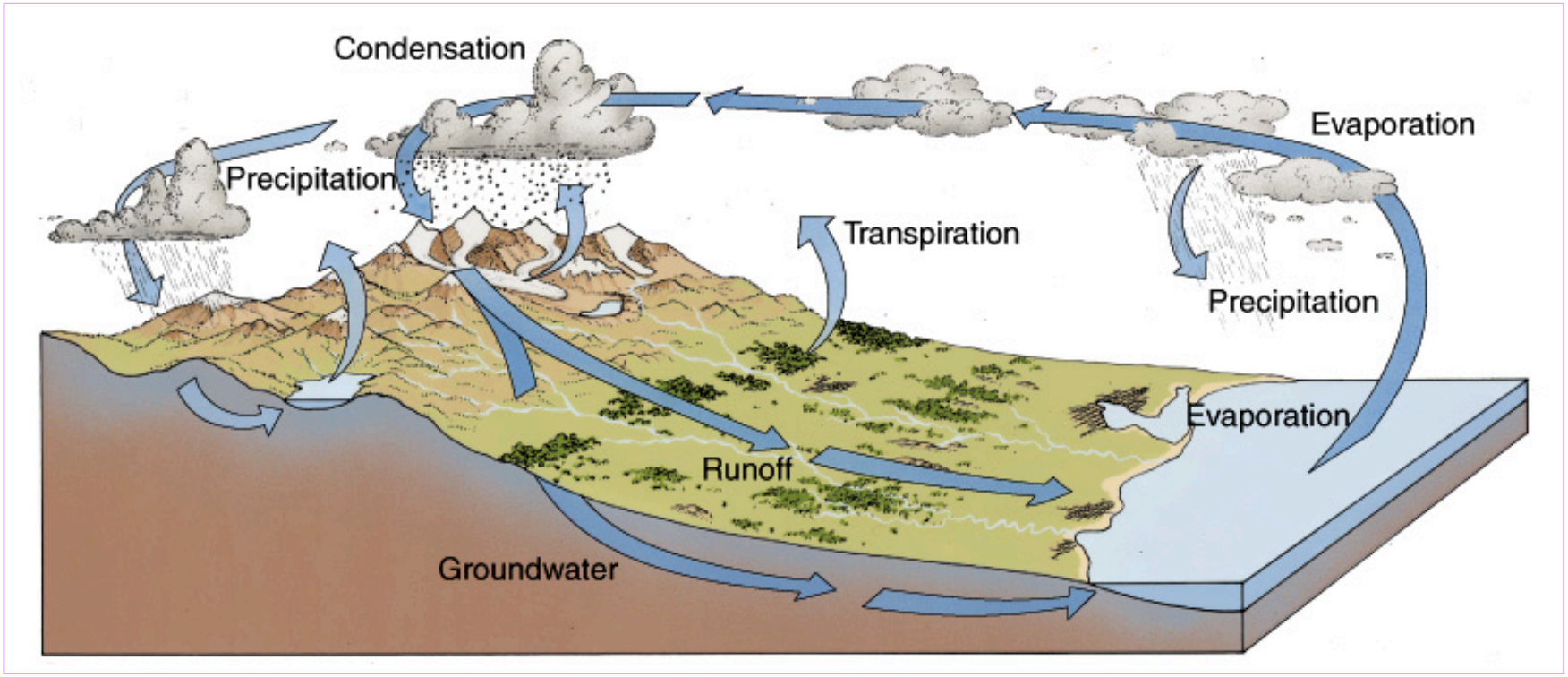
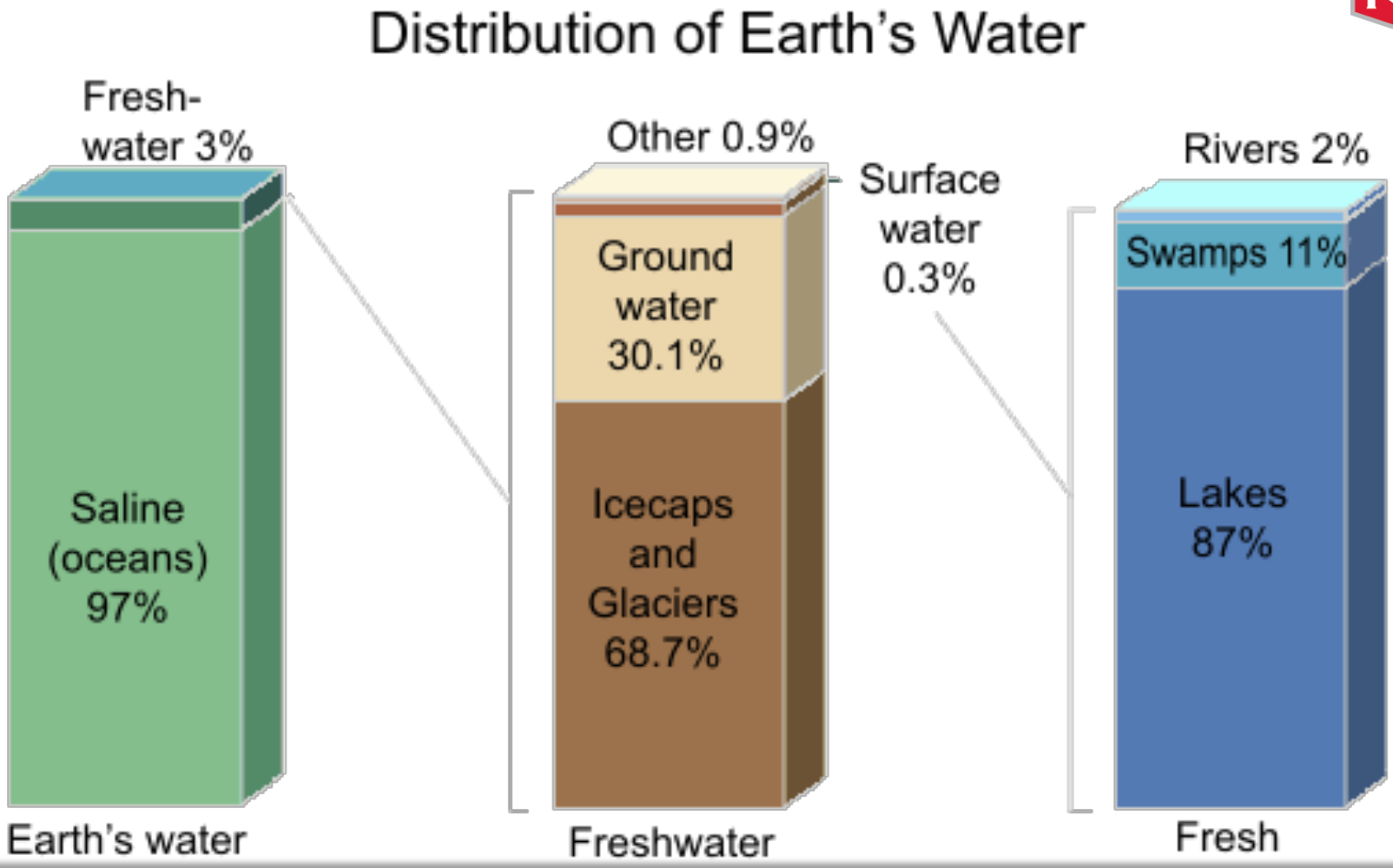
Importance of Groundwater Education

Hydrologic cycle

On a global scale, water is transferred from the oceans, to the atmosphere, to the continents, and back to the oceans.



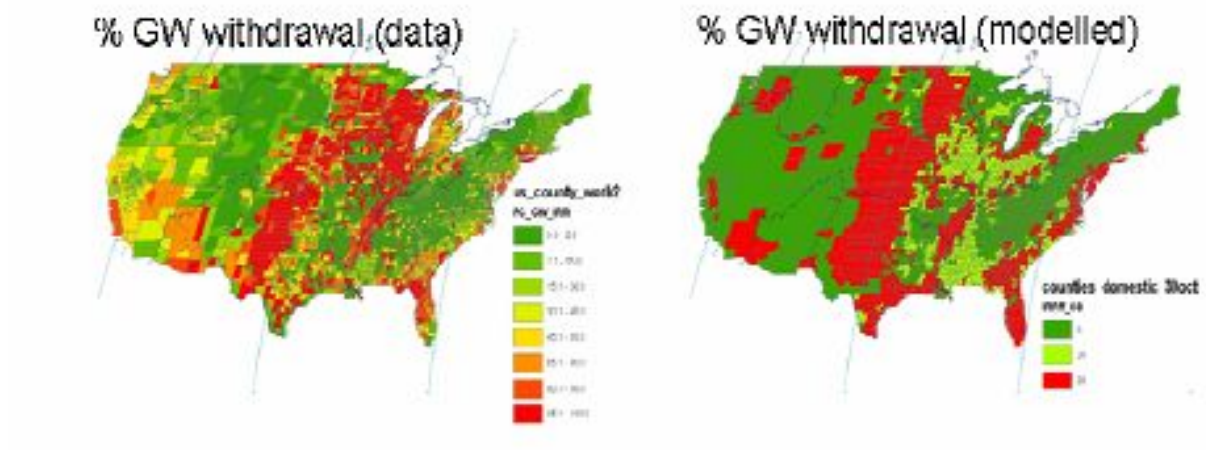
Water reservoirs on Earth



Main Groundwater use

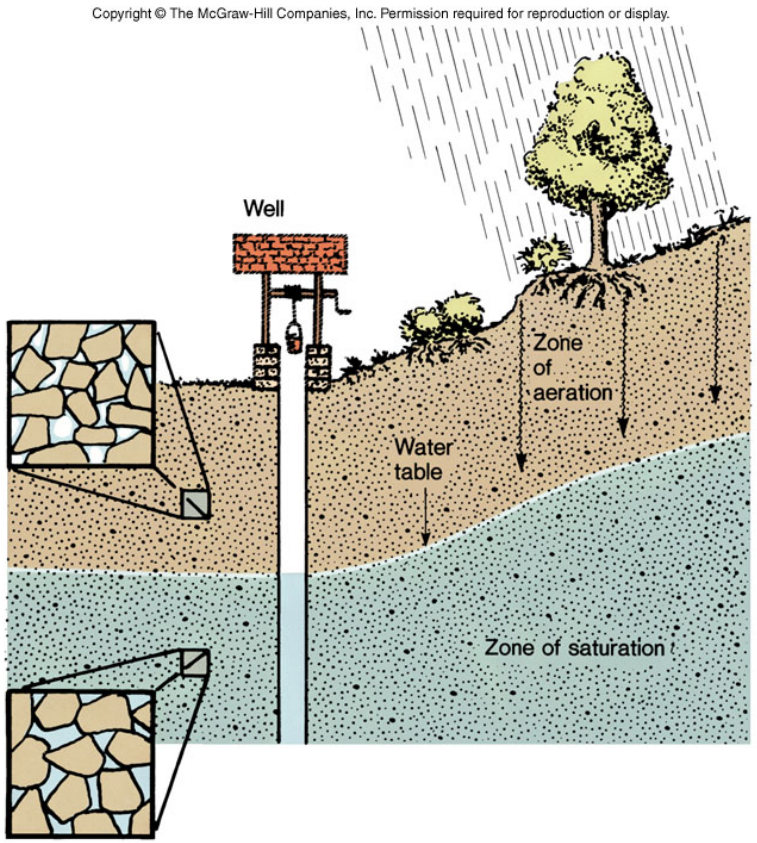
- Lower population areas with most water
- 25% of population of USA drinks groundwater while in rural areas 100%
- Human biologically require 1 gallon of water/day
- We withdrawal 400 billion gallon/day or 1800 gallon/person
  - used for agriculture, livestock, showers, cooking, etc.

(excluding power)

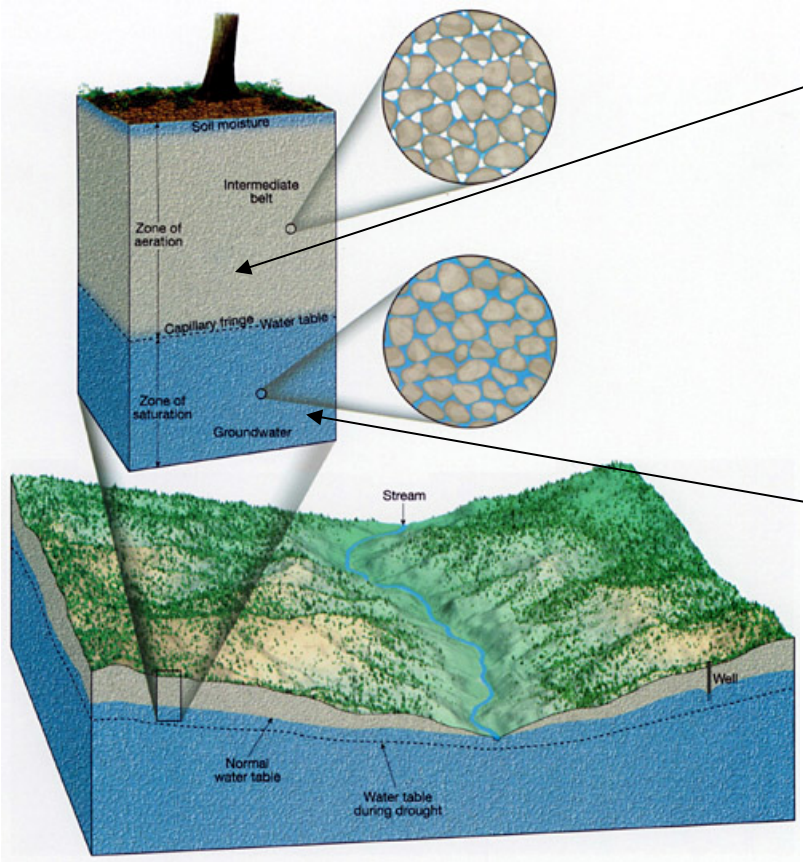


Groundwater

- Water in the zone of saturation below the water table
- Geology influences location and if it can be used as a resource
- Not rivers underground



Groundwater



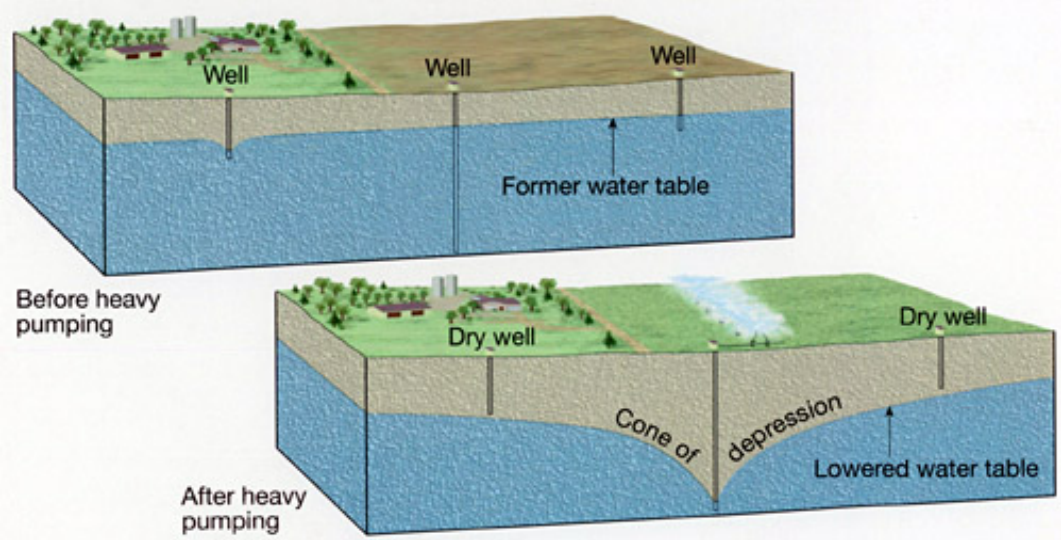
- **Vadose Zone**- unsaturated zone, pores are filled with air or air/water
- **Zone of Saturation** where all the pores are filled up with water

Dug Wells in Myanmar

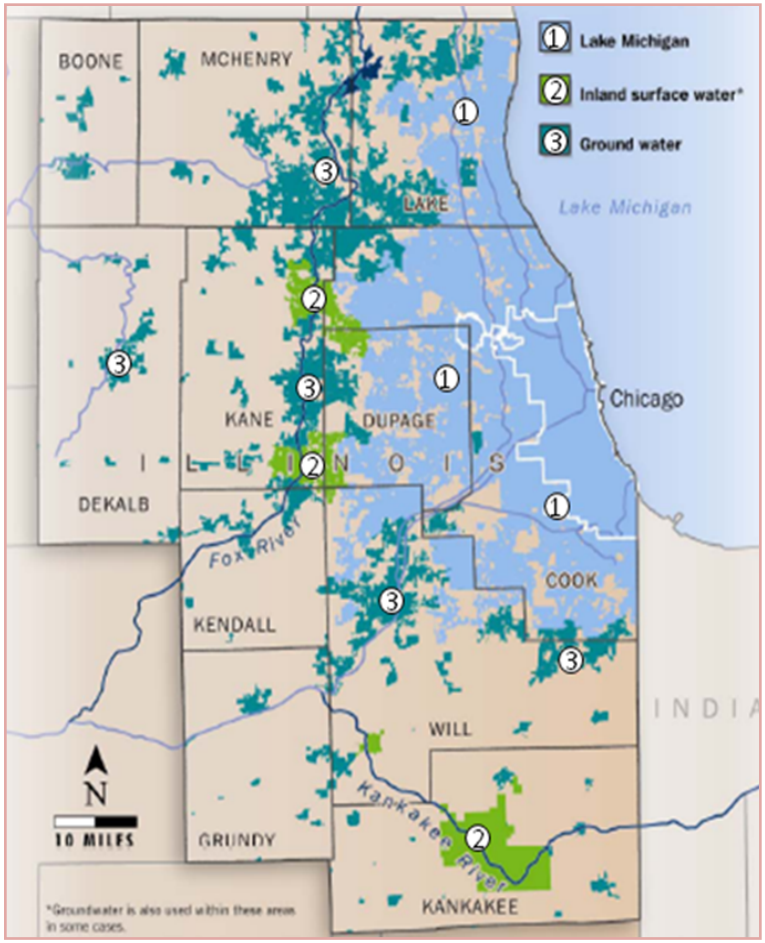
- Dug wells are about 100 years old
- Brick liner
- Community Use
- Cleaning
- Washing
- 20-50 feet deep
- 4-5 feet in diameter

Well

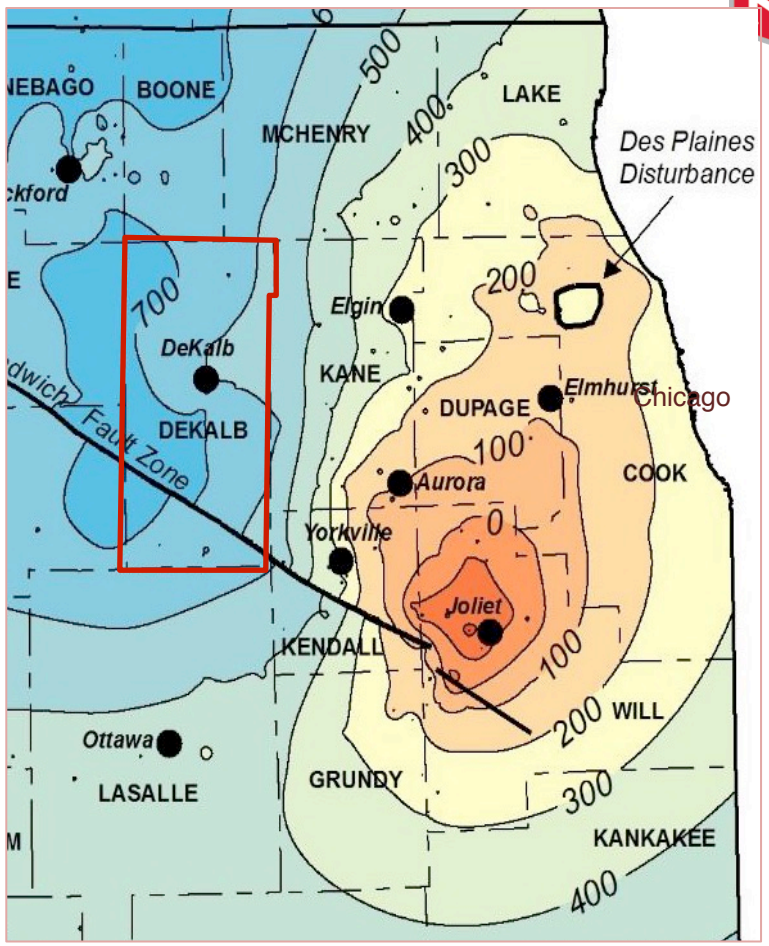
- Tube into the ground that intersects groundwater
- Pumped to get water to the surface



Chicagoland Area

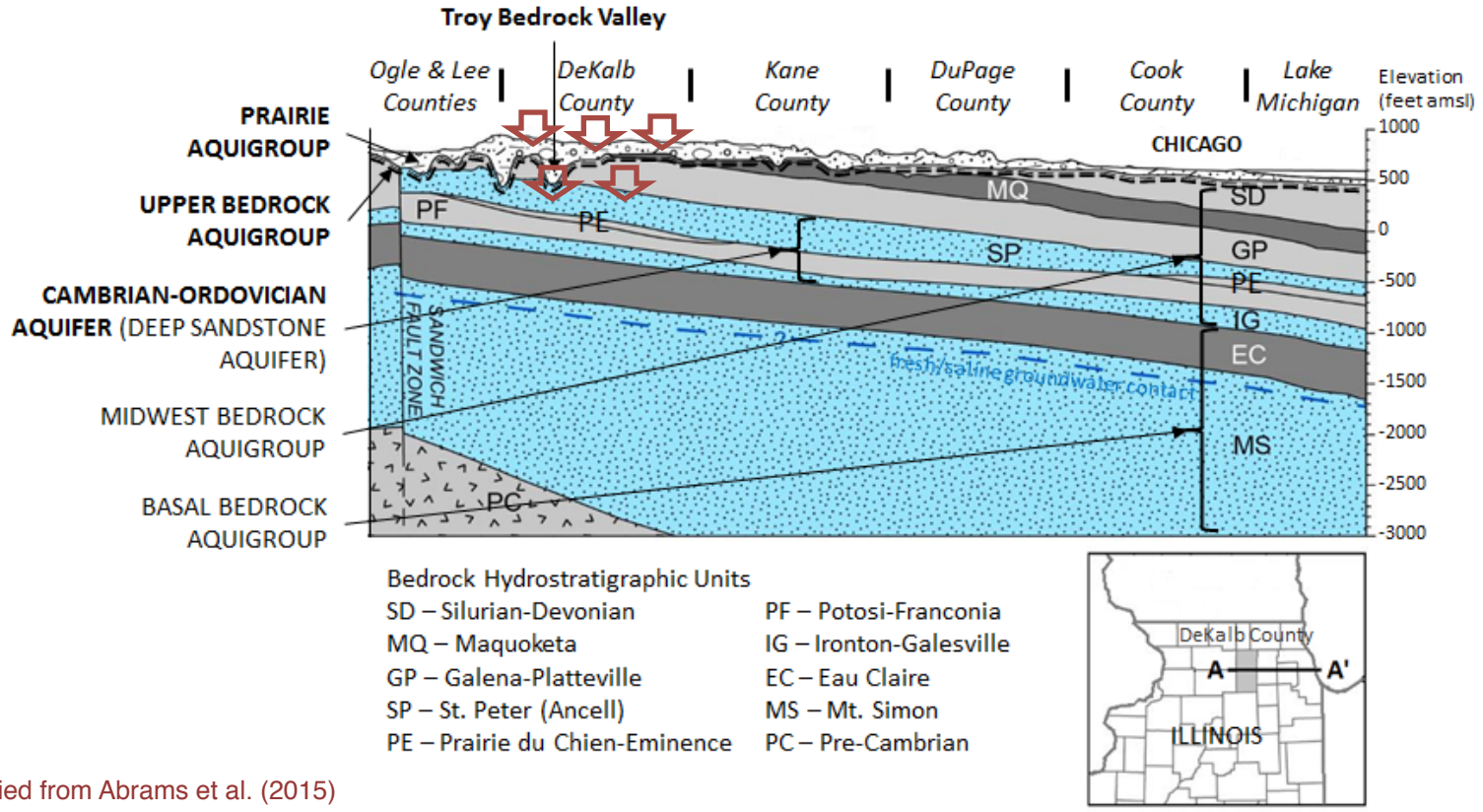


Location of DeKalb County and water resource use areas in northeast Illinois. (modified from CMAP, 2008)



Groundwater elevations in the Deep Sandstone Aquifer in northeastern Illinois, 2014. (Abrams et al., 2015)

Recharge into groundwater



Modified from Abrams et al. (2015)

Regional Bedrock

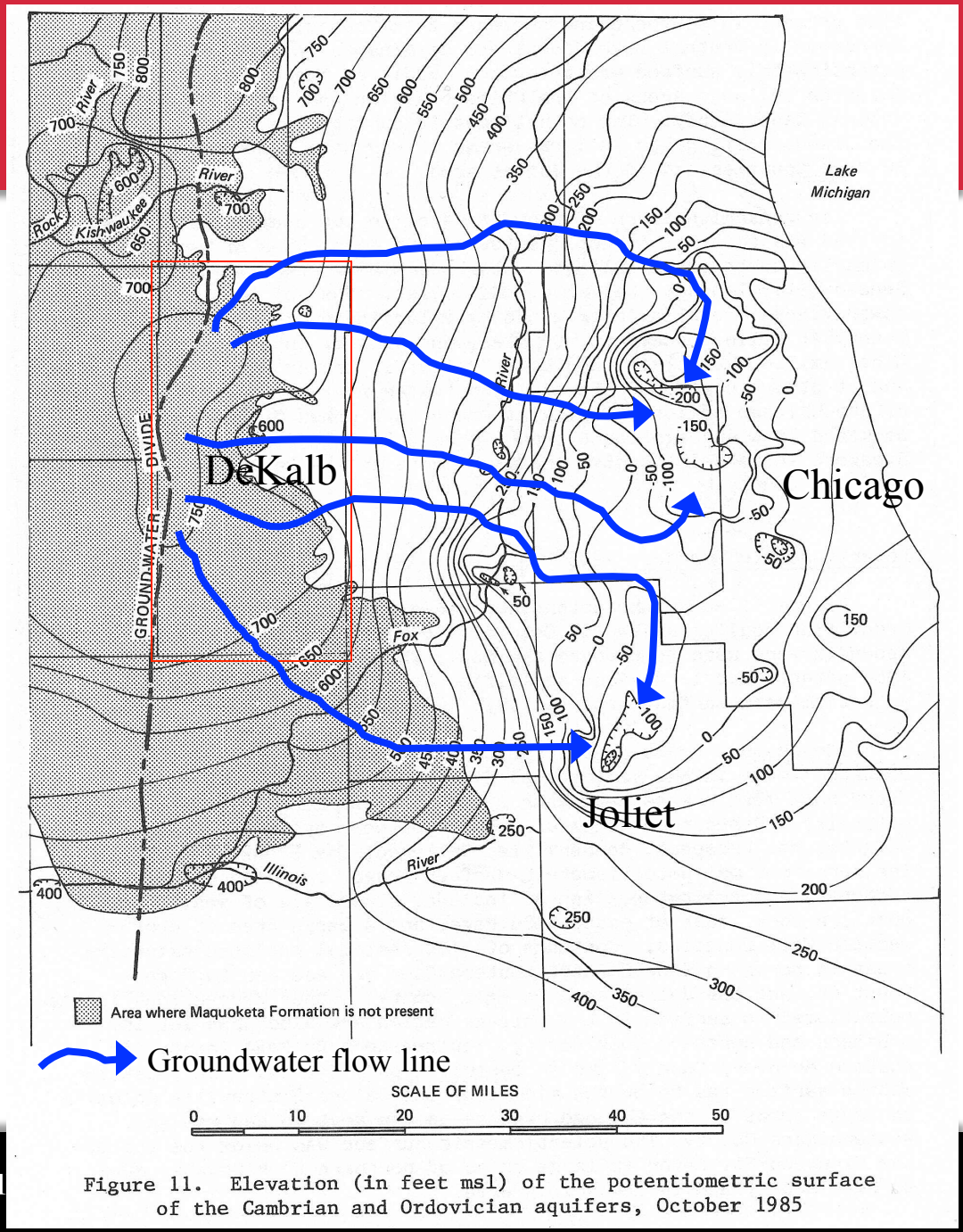
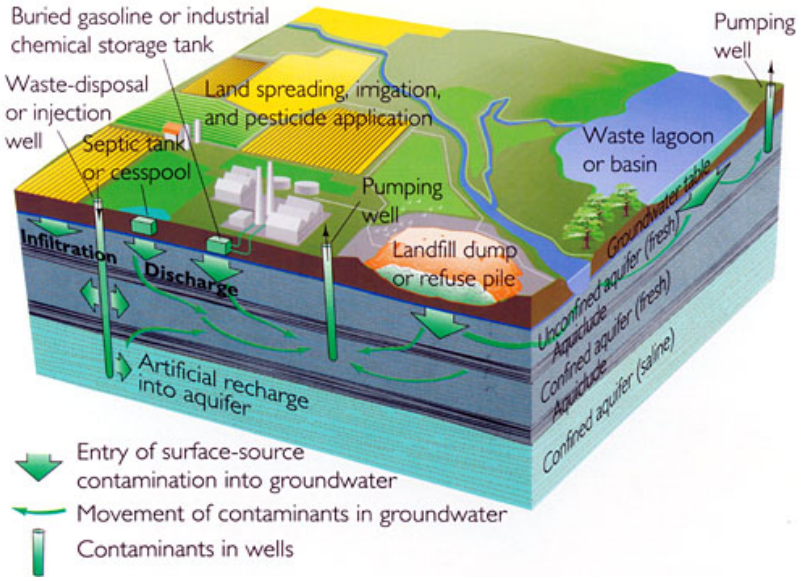


Figure 11. Elevation (in feet msl) of the potentiometric surface of the Cambrian and Ordovician aquifers, October 1985

Groundwater Contamination

Sources

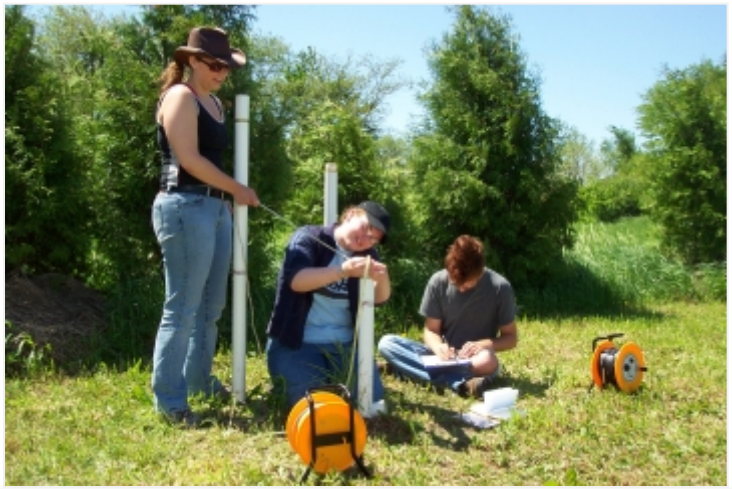


Sciences

- Chemistry
  - Organic (oil, Rx)
  - Inorganic (N, P)
- Biology
  - Pathogens
  - Microbial Communities
- Earth Sciences
  - Geology of site (As, F)
  - Hydrological flow (landfill leachate to stream)
- Math
  - Velocity, gradients
- Engineering
  - Development of sensors

Objectives

- Introduce groundwater sciences
  - Earth sciences, biology, chemistry, environmental sciences, math, engineering
- Hands-on activities on campus
- Curriculum development



IMSA and SIR

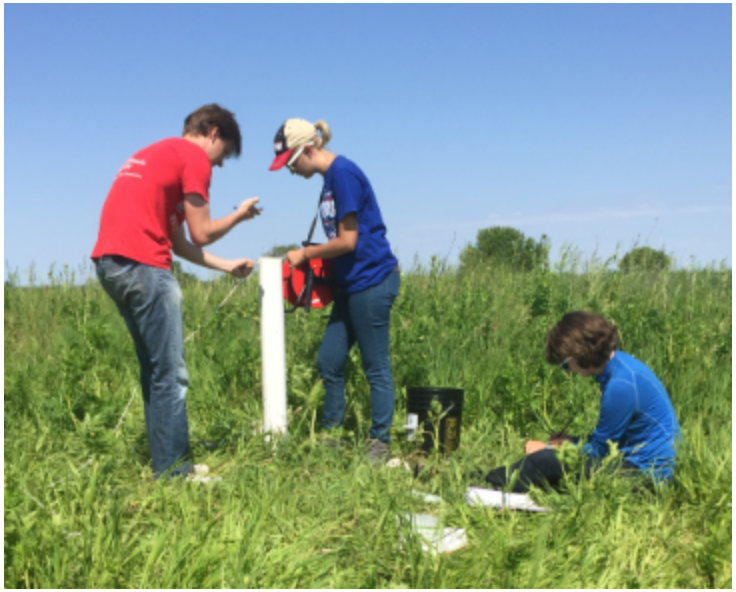
- Partnered with Illinois Math and Science Academy
  - 3 year residential academy
  - Selective for interest in math and science
  - Inquiry based teaching
    - Methods in Science Course
    - Geology course
    - UNSDG focused curriculum
    - Future cross disciplinary environmental courses

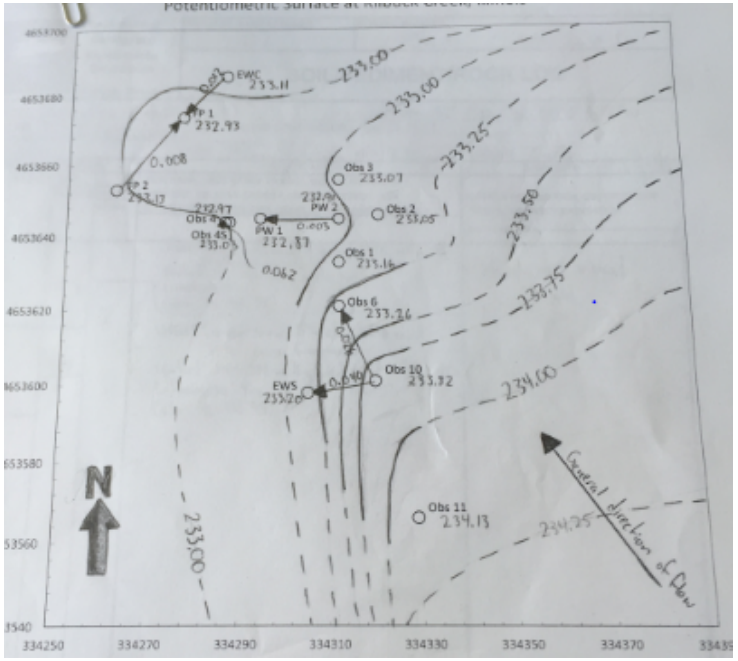
IMSA and SIR

- Scientific Inquiries in Research Program
  - Wednesday is inquiry day with students
  - On and off campus research work
  - Students collaborate with researchers in the field
  - Papers published internally
  - Presentation day with posters and research talks

Development of well field

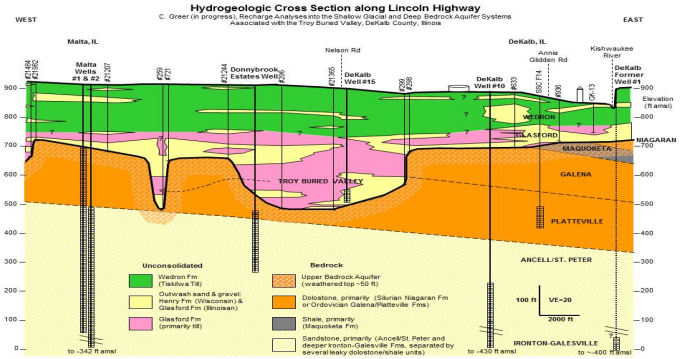
- Inspiration from teaching Environmental Field Camp at NIU

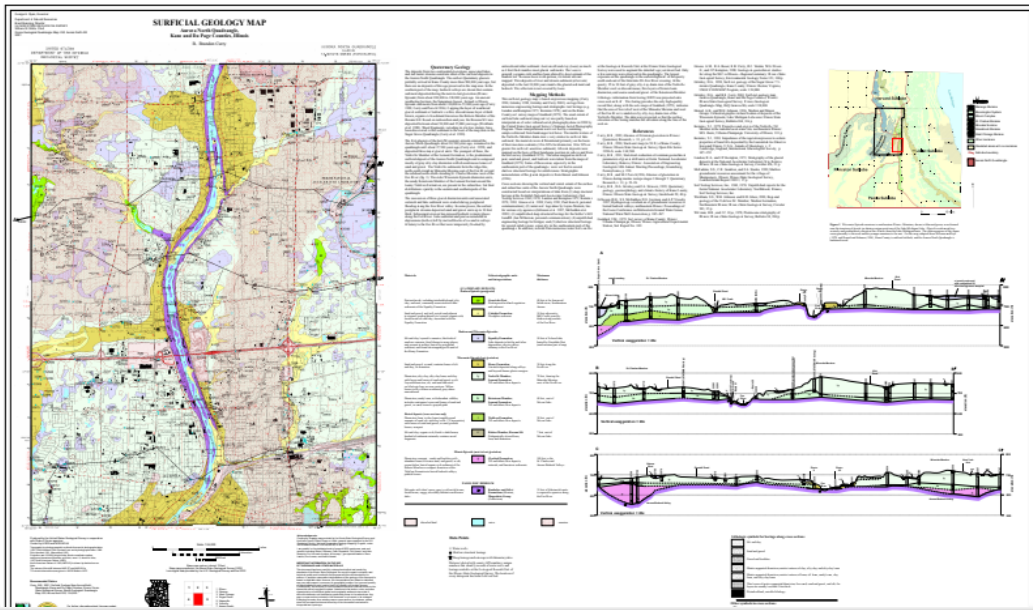




Regional Geology

- Campus Geology
  - Glacial Geology
- Tools:
  - ILWATER (website)
  - Geological Maps

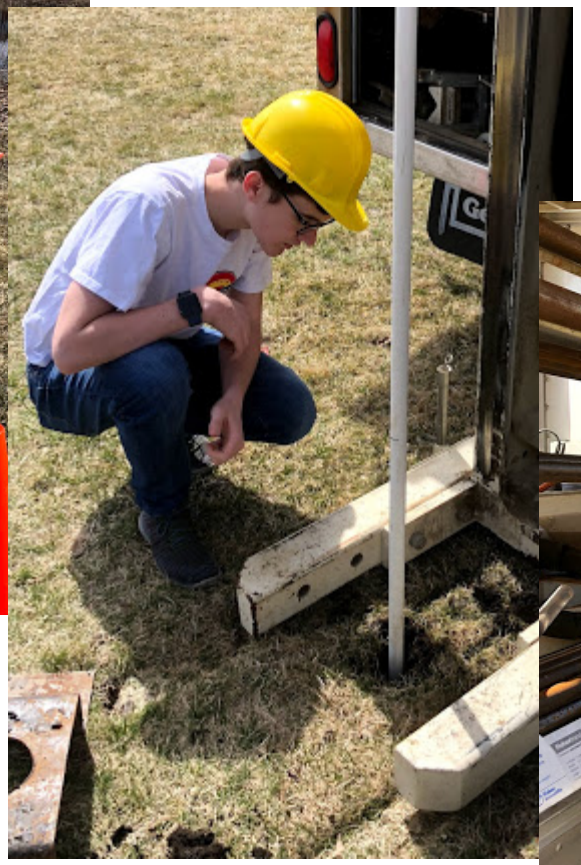




Students determined locations

Drilling and Well Installation

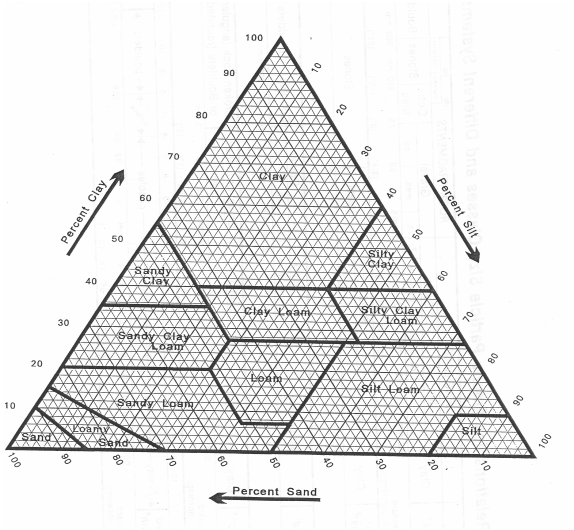
- Drilling methods – NIU's Geoprobe
  - Donation from local drillers
- Well installation – PVC



Your Future. Our Focus.

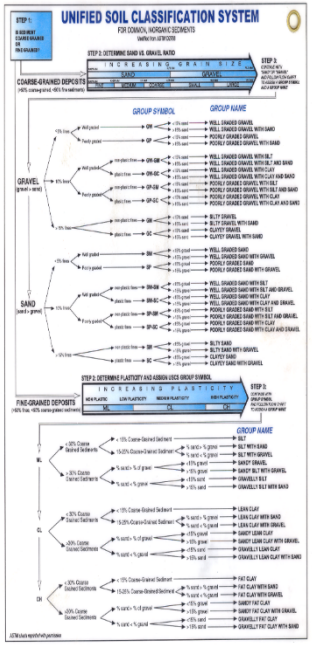
Borehole Logging

- Classification using USCS and USDA systems.
  - focus on glacial and Quaternary materials

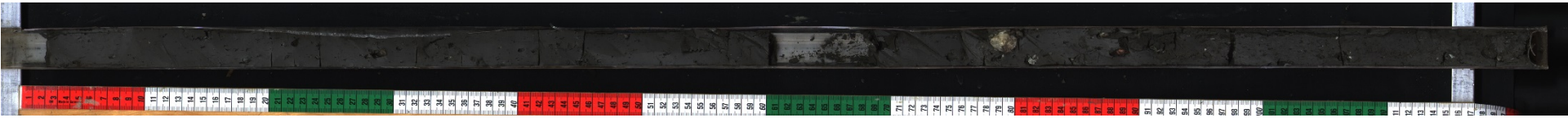


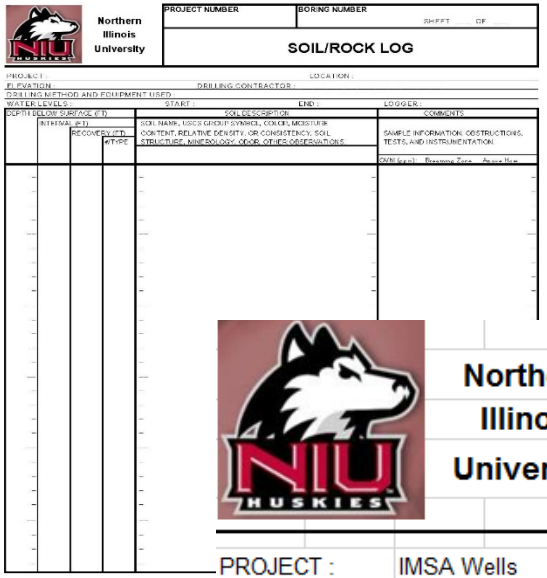
Pictures of cores

- Submit to state geological survey
- Preserve core for a display



Microbiology Sample





Northern Illinois University

PROJECT NUMBER | BORING NUMBER | SHEET __ OF __

SOIL/ROCK LOG

PROJECT : | LOCATION :

ELEVATION : | DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : | START : | END : | LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	#/TYPE	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINEROLOGY, ODOR, OTHER OBSERVATIONS.	COMMENTS: SAMPLE INFORMATION, OBSTRUCTIONS, TESTS, AND INSTRUMENTATION.
					OVM (ppm): Breathing Zone Above Hole

Northern Illinois University

PROJECT NUMBER | BORING NUMBER | SHEET 1 OF 1

SOIL/ROCK LOG

PROJECT : IMSA Wells | LOCATION : IMSA No Pond

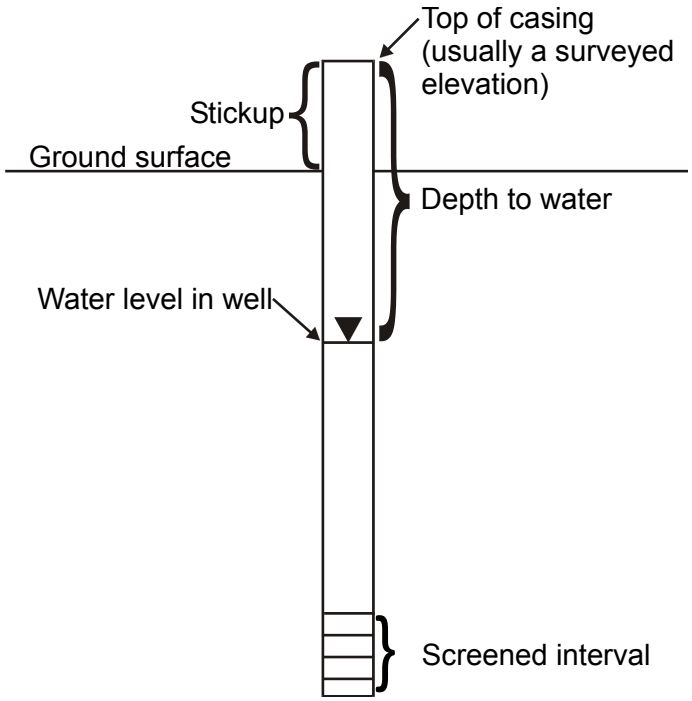
ELEVATION : | DRILLING CONTRACTOR :

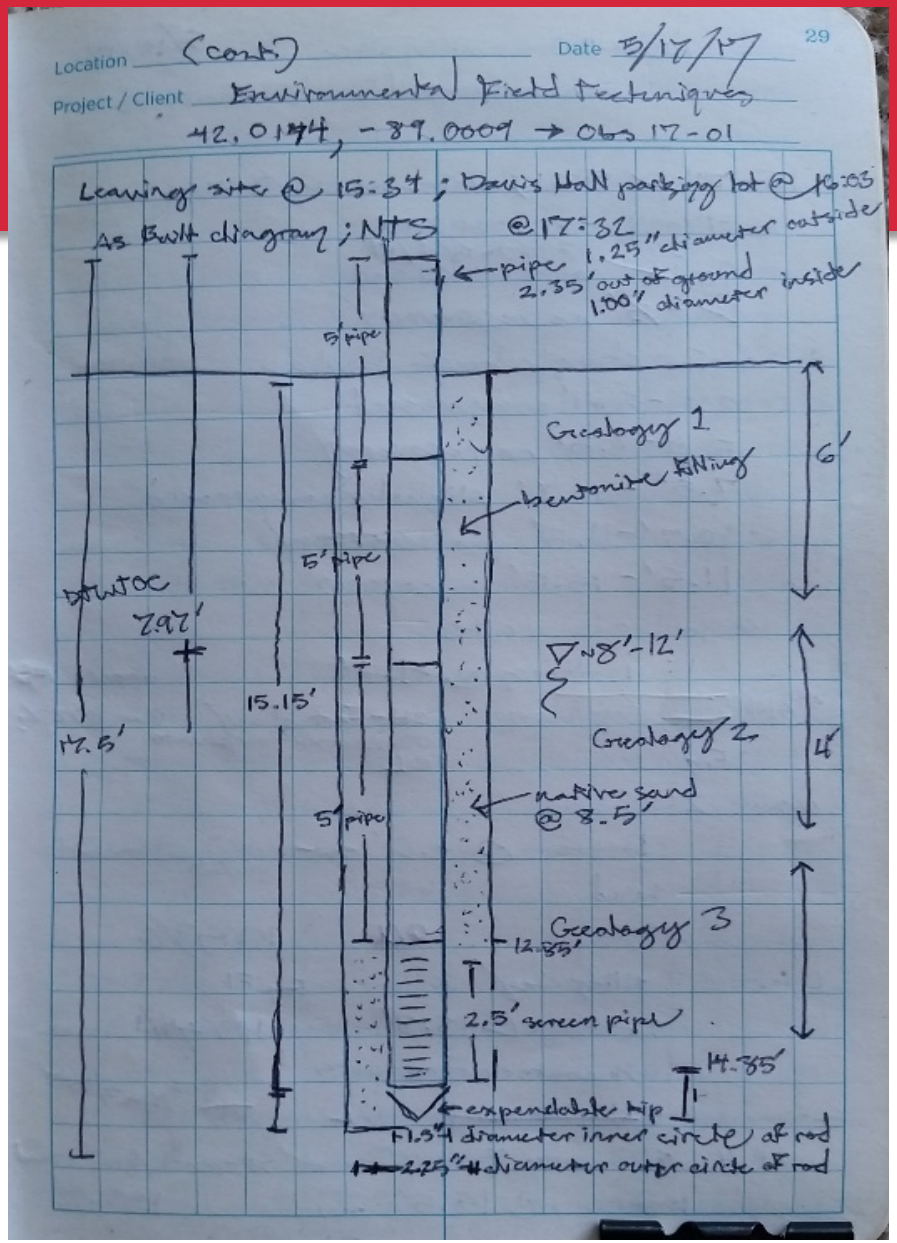
DRILLING METHOD AND EQUIPMENT USED : Geoprobe, 1 inch dual tube system

WATER LEVELS : | START : 0 ft | END : 36 ft | LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	#/TYPE	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINEROLOGY, ODOR, OTHER OBSERVATIONS.	COMMENTS: SAMPLE INFORMATION, OBSTRUCTIONS, TESTS, AND INSTRUMENTATION.
	4 ft.				OVM (ppm): Breathing Zone Above Hole
				0-.75 ft- color: 7.5y 6/4, silty clay (50% clay, 1% CF),strong, granular. effervescent, abrupt boundaries	Soil with grass, light to dark color
		2.1		.75-2 ft color: 2.5y 3/2, silty clay (50% clay, 1% CF), strong granular, gradual boundaries	
				2-3.6 ft color:5y 3/2, silty clay (50% clay, 1% CF), strong, granular, gradual boundaries	
	4				First appearance of clay

Well Installation





Water Levels

- GIS
- Elevations

Well ID	Total Station		
	meters, East	meters, North	TOC, feet
EW 3	334249	4653698	762.654
EW 2	334266	4653695	762.647
EW 1	334276	4653687	762.603
FP 1	334276	4653674	768.979
OBS 4S	334286	4653644	771.663
OBS 4	334287	4653644	776.624
PW 1	334294	4653645	774.635
PW 2	334312	4653646	774.623
OBS 1	334312	4653634	776.89
OBS 00	334312	4653621	776.797
OBS 2	334321	4653646	776.392
OBS 10	334320	4653601	774.898
OBS17-01	334330	4653645	771.172

DTWTOC 5/22,	head elev, ft	total depth, ft	vertical gradient, ft
4.60	764.379	7.17	2.57
7.67	767.228	12.21	4.54
11.56	765.330	29.76	18.20
8.17	763.002	16.91	8.74
11.08	765.312	29.76	18.68
NA	NA	24.89	NA
11.82	764.180	21.88	10.06
6.89	764.773	24.65	17.76
11.31	765.487	29.3	17.99
8.28	768.170	14.47	6.19
9.78	764.843	27.38	17.60
9.42	765.203	28.09	18.67

Water Sampling

- Exposure to a variety of purging and sampling techniques.
  - low flow, parameter stabilization, specified volume
  - QA/QC, sample preservation
  - Organics, inorganics, microbiological

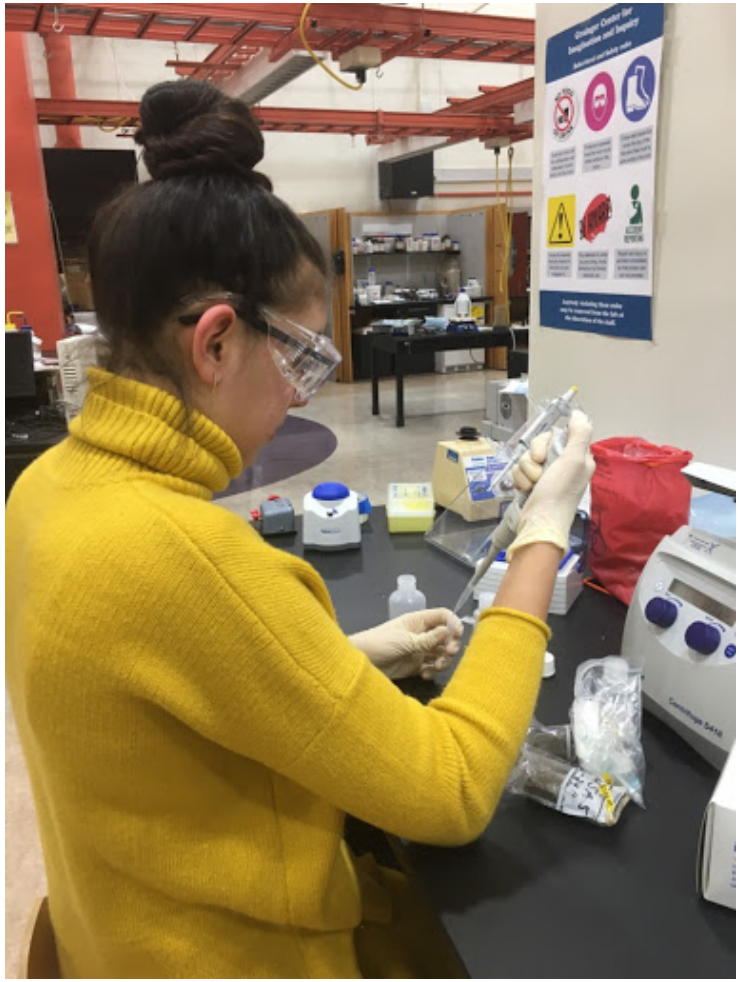
Microbial Community

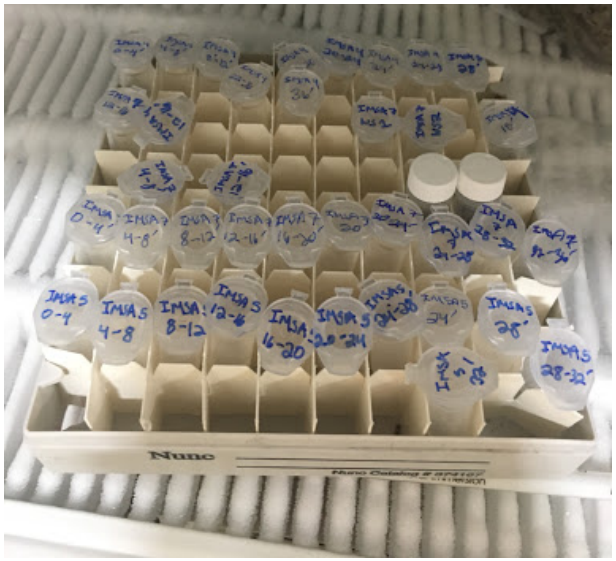
Pathogens- Coliform/*E. coli*

Microbial Community

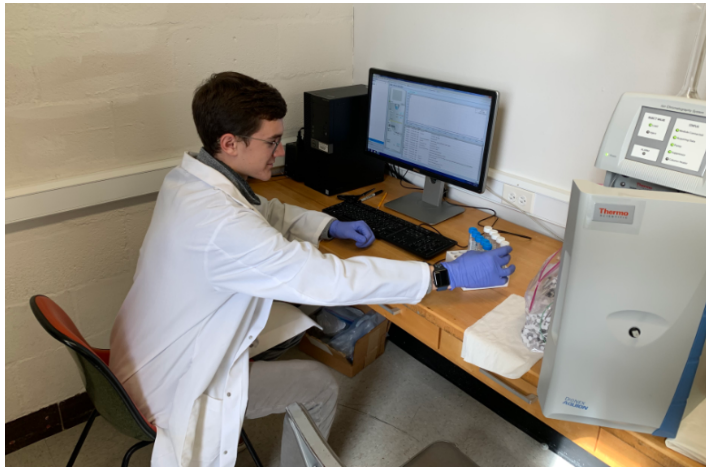
- DNA extract of core with depth and of water
- Compare microbial communities using PCR-Sequencing

Microbial Community





Aqueous Chemistry



Test Type	HACH Testing Kits								
Method	As per manufacturer instructions								
					detection limit				
	Substance being tested for	symbol	sample results	unit	lowest	highest	IL MCL	unit	misc. info.
	Arsenic	As	ND	mg/L	5.00	1000.00	0.05	ppm	NA
	Ammonia	NH3	ND	mg/L	0.00	2.00	NA	NA	NA
	Calcium Hardness	CAS	240.00	mg/L	20.00	400.00	NA	NA	NA
	Nitrate	NO2	0.88	mg/L	0.00	40.00	10.00	ppm	as nitrogen
	Total Hardness	CaCO3	420.00	mg/L	20.00	400.00	NA	NA	NA
	Phosphate	PO4	0.06	mg/L	0.00	50.00	400.00	ppm	proposed
	Phosphorous	P	0.02	mg/L	0.00	50.00	NA	NA	NA
	Magnesium Hardness	Mg	180.00	mg/L	20.00	400.00	NA	NA	NA

Continuous Monitoring

- Water level changes associated with precipitation events
- Weather Station
- Pressure Transducer

Flow between wells

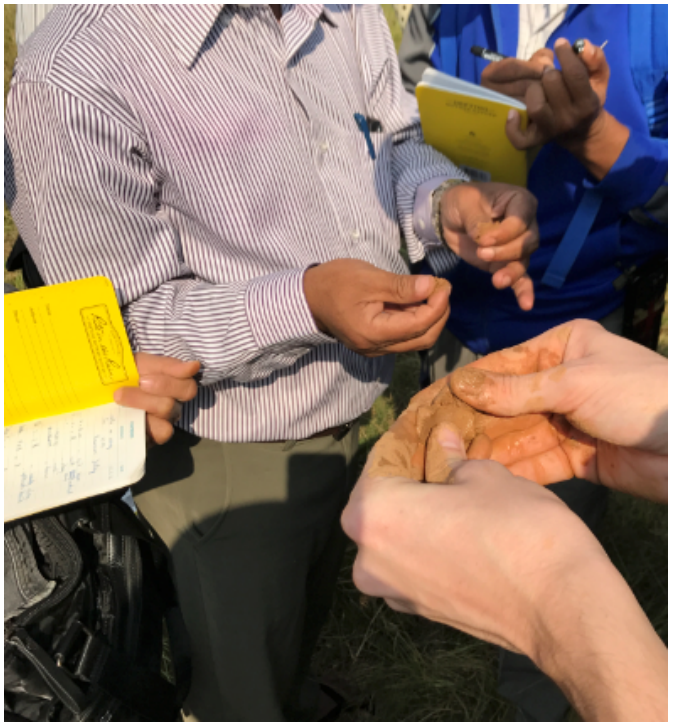
- Three-point problems and hydraulic conductivity
- Conservative tracer
  - NaCl into one well, monitor in others
  - Advective Flow, Disperation, Dilution
- Gradient and velocity

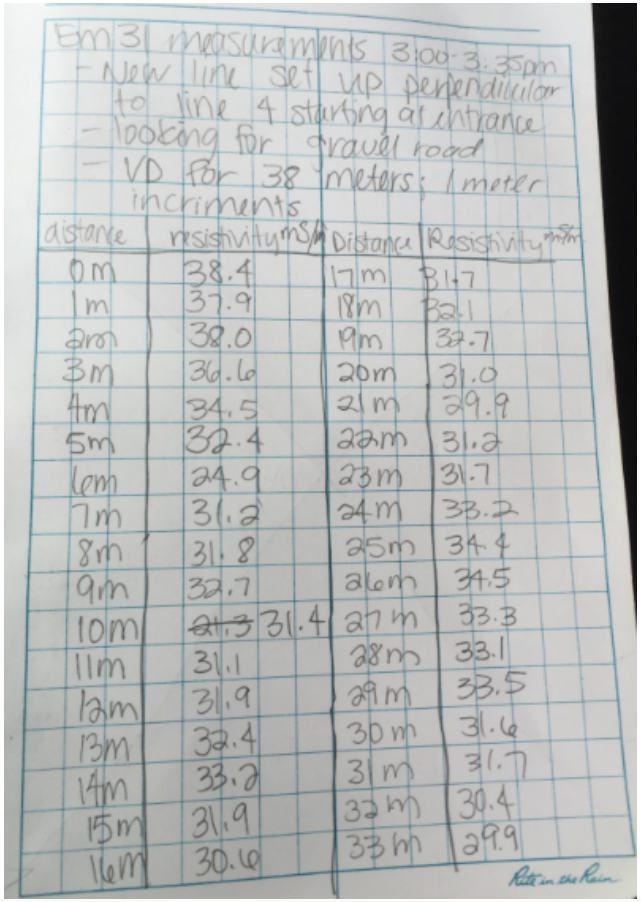
$$K = \frac{r^2 \ln(L/R)}{2L\,T_0}$$

$$K = \frac{r_c^2 \ln\left(R_e/R\right)}{2L_e} \frac{1}{t} \ln\left(\frac{H_o}{H_t}\right)$$

Other exercise

- Field observations and keeping accurate notes



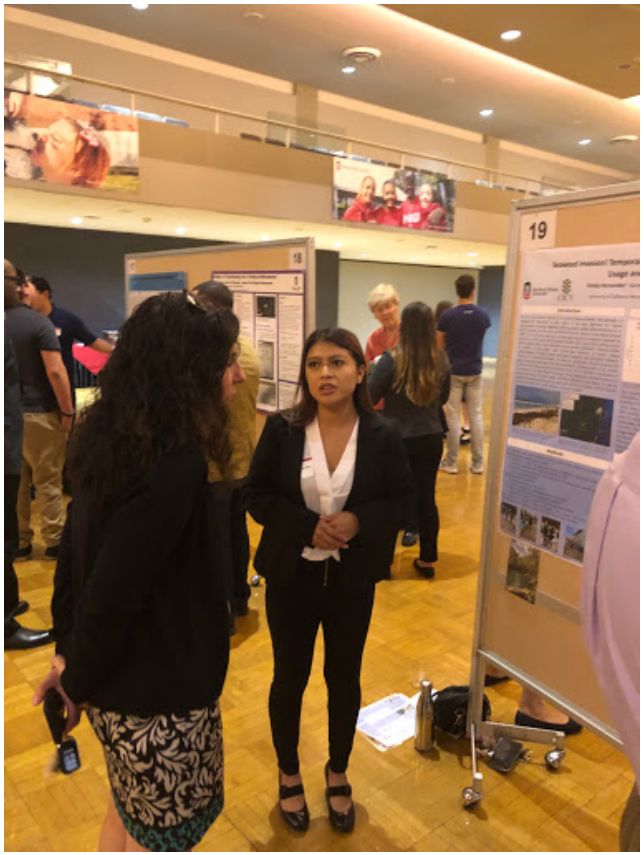


EM31 measurements 3:00-3:35pm
- New line set up perpendicular to line 4 starting at entrance
- looking for gravel road
- VD for 38 meters; 1 meter increments

distance	resistivity mS/m	Distance	Resistivity mS/m
0m	38.4	17m	31.7
1m	37.9	18m	32.1
2m	38.0	19m	32.7
3m	36.6	20m	31.0
4m	34.5	21m	29.9
5m	32.4	22m	31.2
6m	24.9	23m	31.7
7m	31.2	24m	33.2
8m	31.8	25m	34.4
9m	32.7	26m	34.5
10m	~~21.3~~ 31.4	27m	33.3
11m	31.1	28m	33.1
12m	31.9	29m	33.5
13m	32.4	30m	31.6
14m	33.2	31m	31.7
15m	31.9	32m	30.4
16m	30.6	33m	29.9

Presenting Research

- In addition to on campus research presentations and publications, our students are going to share their research more widely
  - Rachel Moreno: presenting at American Society for Microbiology
  - Ethan Phillips: presenting at North Central Geological Society of America



Next Steps

- Formally Write up curriculum for dissemination
- Partner with other schools locally and further abroad
- Engage in longer term collaborative research groups using this model

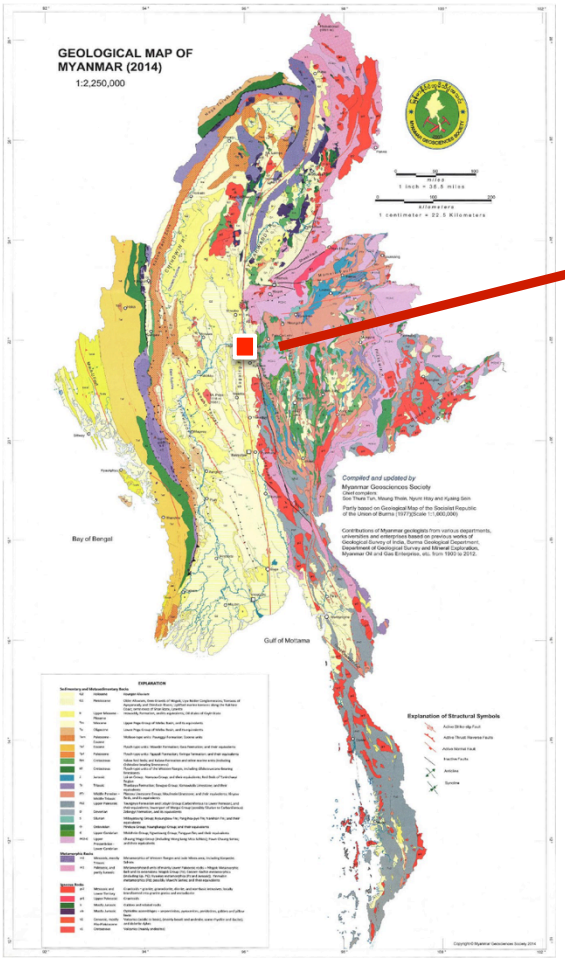
Opportunities for Science Teachers

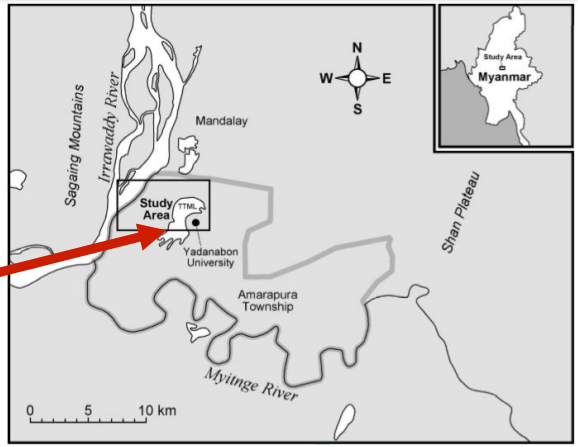
- Interdisciplinary Foreign Research Experience for Teachers (IFRET)
- Summer 2020 (flexible dates between June-July)
- All expenses paid to Southeast Asia (Myanmar) for up to two high school teachers
- Research with Professor
  - Jim Wilson, Medical Geographer
- NIU.edu/ese/ifret

Textile Dyes as a Source of Groundwater Contamination in Mandalay, Myanmar

Surya Freeman

Example Project- Myanmar





(Grzybowski et al., 2019)

Example Project

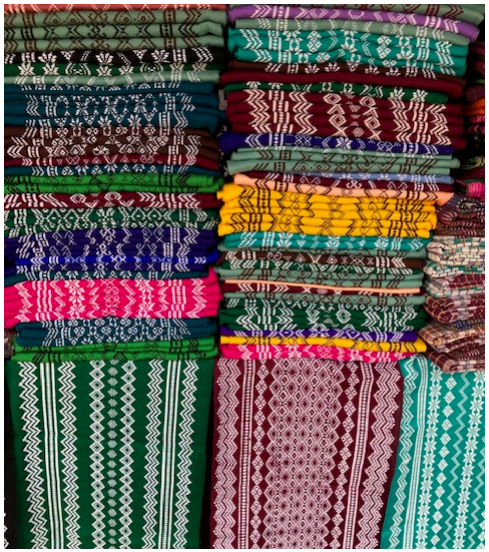
Home to 1.21 million people

Currently lacking:
- wastewater management systems
- solid waste disposal processes
- water treatment facilities

People either use shallow aquifer groundwater or buy bottled water for everyday uses

Textile dyeing and weaving of traditional longyi garments has occurred in the Amarapura Township of Mandalay, Myanmar since 1822

- Dyeing is an unregulated practice
- Colored dyes are bought from China and India



Heavy Metals	Units	RDL	MCL	M1-A	PG1-B	PG1-B	M1-B	M3-B	M6-B
				3/13/2018	3/12/2018	8/7/2018	3/13/2018	8/7/2018	8/8/2018
Aluminum	mg/L	0.1	0.2*	5.12	0.24	0.9	1.66	0.51	3.81
Antimony	mg/L	0.006	0.02					0.713	
Arsenic	mg/L	0.01	0.005						
Barium	mg/L	0.005	0.3						
Beryllium	mg/L	0.004	0.004						
Cadmium	mg/L	0.005	0.003						
Chromium	mg/L	0.005	0.05						
Copper	mg/L	0.005	2*						
Iron	mg/L	0.05	0.3	8.69	0.24	1.06	1.58	0.73	1.92
Lead	mg/L	0.005	0.01*	0.271			0.046		0.045
Manganese	mg/L	0.005	0.4*						
Nickel	mg/L	0.005	0.02*			0.122			
Selenium	mg/L	0.01	0.01						
Silver	mg/L	0.005	0.1						
Sodium	mg/L	0.5	200*	523	1090	2960	373		624
Thallium	mg/L	0.01	0.002	0.002					
Zinc	mg/L	0.01	3*						
				Effluent Release Points					

*** Indicate WHO Health Guidelines when MCL is absent**

Values above MCL or WHO Guidelines
Values below the RDL
Values below the MCL or WHO Guidelines

Questions?

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